NEBRASKA
SCIENCE STANDARDS
Grades K-12

Adopted by the State Board of Education
May 8, 1998

Nebraska Department of Education
P.O. Box 94987
301 Centennial Mall South
Lincoln, Nebraska 68509-4987
Telephone: (402) 471-4329
Fax: (402) 471-0117
Email: jim.woodland@nde.ne.gov
Website: http://www.nde.state.ne.us

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GENERAL INFORMATION

Investigate and Understand

Many of the Nebraska K-12 Science Standards contain the words investigate and understand. These words were chosen to communicate the range of rigorous science skills and knowledge levels embedded in each standard. Limiting a standard to one observable behavior, such as "describe" or "explain," would have narrowed the interpretation of the rich, highly rigorous, and inclusive content standard.

"Investigate" refers to scientific methodology and implies systematic use of the following inquiry skills:

- Observing
- Classifying and sequencing
- Communicating
- Measuring
- Predicting
- Hypothesizing
- Inferring
- Defining, controlling, and manipulating variables in experimentation
- Designing, constructing, and interpreting models
- Interpreting, analyzing, and evaluating data

"Understand" refers to various levels of knowledge application. In the Nebraska K-12 Science Standards these knowledge levels include the ability to:

- Recall or recognize important information, key definitions, terminology, and facts.
- Explain the information in one's own words, comprehend how the information is related to other key facts, and suggest additional interpretations of its meaning or importance.
- Apply the facts and principles to new problems or situations, recognize what information is required for a particular situation, explain new phenomena with the information, and determine when there are exceptions.
- Analyze the underlying details of important facts and principles, and recognize the key relations and patterns that are not always readily visible.
- Arrange and combine important information, facts, and principles to produce a new idea, plan, procedure, or product.
- Make judgments about information in terms of accuracy, precision, consistency, or effectiveness.

The level of achievement in investigation and understanding will vary based on the average developmental level of students in grades 1, 4, 8, and 12. This also allows flexibility in establishing the scope and sequence of investigative skills and understanding.

Therefore, the use of "investigate" and "understand" allows each content standard to become the basis for a broad range of teaching objectives, which the local school will develop and refine to meet the intent of the Nebraska K-12 Science Standards.

Unifying Concepts and Processes

Systems, Order, and Organization

Systems–A system is an organized group of related objects or components that form a whole. Systems can consist, for example, of organisms, machines, fundamental particles, galaxies, ideas, numbers, transportation, and education. The goal is to help students think and analyze in terms of systems.

Order–Order is the behavior of units of matter, objects, organisms, or events in the universe. The goal is to help students develop knowledge about factors influencing objects, organisms, systems, or events.

Organization–Organization is a hierarchic and systematic way of thinking about the world. The goal is to help students describe physical and living systems at different levels of organization.

Evidence, Models, and Explanations

Evidence–Evidence consists of observations and data on which to base scientific explanations. The goal is to help students use evidence to understand interactions and predict changes.

Models–Models are tentative schemes or structures that correspond to real objects, events, or classes of events, and that have explanatory power. The goal is to help students learn how to make and use many models, including physical objects, plans, mental constructs, mathematical equations, and computer simulations.

Explanations–Explanations provide interpretation, meaning, or sense to objects, organisms, or events. Explanations incorporate existing scientific knowledge and new evidence from observations, experiments, or models into internally consistent, logical statements, such as hypotheses, laws, principles, and theories. The goal is to help students create explanations which incorporate a scientific knowledge base, logic, and higher levels of analysis.

Constancy, Change, and Measurement

Constancy–Constancy is uniformity in nature, value, and extent. The goal is to help students recognize those conditions or values that cannot change or be changed.

Change–Change denotes making something different. Changes in systems vary in rate, scale, and pattern, including trends and cycles. The goal is for students to identify and measure changes in properties of materials, positions of objects, motion, and form and function of systems.

Measurement–Measurement makes quantitative observations about objects, events, or systems. The goal is to help students use tools of measurement and measurement systems and to achieve understandings of scales and rates.

Form and Function

Form–Form is the shape of an object. The goal is for students to use form to explain function.

Function–Function is the normal or characteristic action of anything. The goal is for students to use function to explain form.

Evolution and Equilibrium

Evolution–Evolution is a series of changes, some gradual and some sporadic, that account for the present form and function of objects, organisms, and natural and designed systems. The goal is for students to recognize that objects & systems change over time.

Equilibrium–Equilibrium is the physical state in which forces and changes occur in opposite and off-setting directions. The goal is for students to recognize systems that are in equilibrium.

Coordination with Mathematics

Science requires the use of mathematics in the collection and treatment of data and in the reasoning used to develop concepts, laws, and theories. The mathematics that students should understand and use in the study of science are listed below.

Kindergarten - First Grade

1. Measure, collect, and organize data.
2. Recognize and describe patterns.
3. Develop skills of estimation and judgment.

Second - Fourth Grade

1. Measure, collect, and organize data.
2. Recognize and describe patterns.
3. Develop skills of estimation and judgment.
4. Explore chance.
5. Use variables to express relationships.

Fifth - Eighth Grade

1. Represent situations verbally, numerically, graphically, geometrically, or symbolically.
2. Use estimations.
3. Identify and use functional relationships.
4. Develop and use tables, graphs, and rules to describe situations.
5. Use statistical methods to describe, analyze, evaluate, and make decisions.
6. Use geometry in solving problems.
7. Create experimental and theoretical models of situations involving probabilities.

Ninth - Twelfth Grade

1. Develop ability to use realistic applications and modeling in trigonometry.
2. Understand connections within a problem situation, its model as a function in symbolic form, and the graph of that function.
3. Use functions that are constructed as models of real-world problems.
4. Know how to use statistics and probability.

Grades K-1

In the primary grades, students should learn science at their developmental level. Young children develop concepts, vocabulary, and inquiry skills by observing common materials and organisms. When engaged in science inquiry, they develop the ability to ask questions, investigate the world around them, and use their observations to create reasonable explanations for their questions.

1.1 Unifying Concepts and Processes

Unifying concepts and processes help students think about and integrate a range of basic ideas which builds an understanding of the natural world.

1.1.1 By the end of first grade, students will develop an understanding of systems, order, and organization.

Example Indicators

- Use one or more of the five senses to observe and describe objects.
- Sort objects by their characteristics.

1.1.2 By the end of first grade, students will develop an understanding of evidence, models, and explanation.

Example Indicator

- Describe how a model (e.g., photos, maps, globes, illustrations, stuffed animals, toys, and building blocks) can represent an object, living thing, or an event.

1.1.3 By the end of first grade, students will develop an understanding of change, constancy, and measurement.

Example Indicators

- Observe and measure change.
- Describe how things change in some ways and stay the same in others.
- Compare two or more objects using direct comparisons of measurement (e.g., shorter, longer, taller, heavier, and lighter).
- Use both standard units of measurement (e.g., inches and centimeters) and nonstandard units of measurement (e.g., string and paper clips).
- Use appropriate measurement systems for different purposes.

1.1.4 By the end of first grade, students will develop an understanding of form and function.

Example Indicators

- Demonstrate how the shape of a tool is related to its use.
- Explain how specific characteristics of living things influence how they interact with their environment (e.g., how the long neck of the giraffe and webbed feet on a duck help them to reach their food).

1.2 Science as Inquiry

Science as inquiry requires students to combine processes and scientific knowledge with scientific reasoning and critical thinking to develop their understanding of science.

1.2.1 By the end of first grade, students will develop the abilities needed to do scientific inquiry.

Example Indicators

- Ask questions about their surroundings.
- Collect scientific information from careful observation.
- Use simple equipment and tools (e.g., rulers, magnifiers) to extend the senses.
- Share findings with classmates, families, or community members.

1.3 Physical Science

Physical science focuses on science facts, concepts, principles, theories, and models that are important for all students to know, understand, and use.

1.3.1 By the end of first grade, students will develop an understanding of the characteristics of materials.

Example Indicators

- Observe and describe characteristics of common materials (e.g., paper, wood, metal, and wool).
- Observe and describe properties of common materials (e.g., how they will float, sink, mix, dissolve, or not dissolve in various liquids).
- Observe and classify materials as a solid, liquid, or gas.

1.4 Life Science

Life science focuses on science facts, concepts, principles, theories, and models that are important for all students to know, understand, and use.

1.4.1 By the end of first grade, students will develop an understanding of the characteristics of living things.

Example Indicators

- Differentiate between living and nonliving things.
- Investigate how living things need food, water, and air to survive.
- Describe how roots, stems, and leaves serve different functions for plants.
- Compare and contrast animals by specific characteristics (e.g., body covering, diet, and locomotion).
- Observe and match organisms to their distinct habitats.

1.4.2 By the end of first grade, students will develop an understanding of the life cycles of organisms.

Example Indicators

- Describe how living things change as they grow.
- Describe how offspring resemble their parents.

1.5 Earth and Space Science

Earth and space science focuses on science facts, concepts, principles, theories, and models that are important for all students to know, understand, and use.

1.5.1 By the end of first grade, students will develop an understanding of the characteristics of earth materials.

Example Indicators

- Observe and identify a variety of materials (e.g., rock, soils, and water) that makes up the earth's surface.
- Identify materials of earth (e.g., water) support life.

1.5.2 By the end of first grade, students will develop an understanding of the objects in the sky.

Example Indicators

- Recognize objects in the sky (e.g., the sun, moon, and stars).
- Investigate that the sun provides heat and light.

1.5.3 By the end of first grade, students will develop an understanding of the changes in the earth and sky.

Example Indicators

- Describe and record daily weather changes.
- Describe and record seasonal weather changes.

1.6 Science and Technology

An understanding of science and technology establishes connections between the natural and designed world, linking science and technology.

1.6.1 By the end of first grade, students will develop an understanding of technological design.

Example Indicator

- Explain how the use of common household tools is determined by their design.

1.6.2 By the end of first grade, students will develop an understanding of science and technology.

Example Indicators

- Use various tools (e.g., magnifiers, thermometers, or rulers) to improve observations and measurements.
- Identify the technology used in different occupations.

1.7 Science in Personal and Social Perspectives

A personal and social perspective of science helps a student to understand and act on personal and social issues. This perspective builds a foundation for future decision making.

1.7.1 By the end of first grade, students will develop an understanding of personal health.

Example Indicators

- Identify safety rules for home and school.
- Engage in personal care that will maintain and improve health.
- Describe a healthy diet.
- Explain that substances can benefit or damage the way the body functions.

1.7.2 By the end of first grade, students will develop an understanding of resources.

Example Indicator

- Observe and describe how reducing, reusing, and recycling help our environment.

1.8 History and Nature of Science

The history and nature of science illustrates different aspects of scientific inquiry, the human aspects of science, and the role that science has played in the development of various cultures.

1.8.1 By the end of first grade, students will develop an understanding of science as a human endeavor.

Example Indicators

- Recognize the contributions to science made by men and women from many places.
- Conduct an investigation as part of a team.

Grades 2-4

In the intermediate grades, students learn science concepts, vocabulary, and inquiry skills at their developmental level. Students should develop knowledge and process skills while engaged in science inquiry. They should ask simple questions, design and conduct investigations (in the form of a "fair" test), and present their results to others.

4.1 Unifying Concepts and Processes

Unifying concepts and processes help students think about and integrate a range of basic ideas which builds an understanding of the natural world.

4.1.1 By the end of fourth grade, students will develop an understanding of systems, order, and organization.

Example Indicators

- Describe the parts that make up a system.
- Relate how the parts of a system affect the whole system.

4.1.2 By the end of fourth grade, students will develop an understanding of evidence, models, and explanation.

Example Indicators

- Use evidence gathered from an investigation to develop a scientific explanation.
- Create a model, graph, or illustration that represents an object, living thing, or an event.
- Explain and answer questions about a model and how it represents an object, living thing, or an event.
- Explain procedures or ideas in more than one way (e.g., sketches, charts, and graphs).

4.1.3 By the end of fourth grade, students will develop an understanding of change, constancy, and measurement.

Example Indicators

- Describe observable changes (e.g., speed, pattern, shape, position, and size).
- Measure a change using appropriate tools and units of measurement.

4.1.4 By the end of fourth grade, students will develop an understanding of form and function.

Example Indicator

- Construct a device to perform a simple task and explain how it works.

4.2 Science As Inquiry

Science as inquiry requires students to combine processes and scientific knowledge with scientific reasoning and critical thinking to develop their understanding of science.

4.2.1 By the end of fourth grade, students will develop the abilities needed to do scientific inquiry.

Example Indicators

- Ask a question about objects, organisms, and events in their surroundings.
- Plan and conduct a simple investigation.
- Use simple equipment and tools (e.g., thermometers and scales) to gather data and extend the senses.
- Use data develop reasonable explanations.
- Communicate procedures, results, and explanations of an investigation.

4.3 Physical Science

Physical science focuses on the science facts, concepts, principles, theories, and models that are important for all students to know, understand, and use.

4.3.1 By the end of fourth grade, students will develop an understanding of the characteristics of objects and materials.

Example Indicators

- Classify objects by observable characteristics (shape, size, and color).
- Compare and contrast characteristics of common materials using tools (e.g., rulers, scales, thermometers, microscopes, and hand lenses).
- Demonstrate that materials can change from solid to liquid to gas by heating and from gas to liquid to solid by cooling.

4.3.2 By the end of fourth grade, students will develop an understanding of the position and motion of objects.

Example Indicators

- Use reference points to describe the position of an object.
- Describe an object's motion by tracing its position over time.
- Demonstrate that the position and motion of objects can be changed by pushing or pulling.
- Demonstrate how sound is produced when objects vibrate.
- Change the pitch of sound by changing the rate of vibration.

4.3.3 By the end of fourth grade, students will develop an understanding of light, heat, electricity, and magnetism.

Example Indicators

- Distinguish between reflection and refraction of light.
- Identify ways in which heat can be produced (e.g., burning, rubbing, or mixing one substance with another).
- Demonstrate heat can flow from one object to another by conduction.
- Use electricity to produce heat, sound or magnetic effects.
- Demonstrate electrical circuits require a complete loop through which an electrical current can pass.
- Describe the physical properties of magnets.

4.4 Life Science

Life science focuses on the science facts, concepts, principles, theories, and models that are important for all students to know, understand, and use.

4.4.1 By the end of fourth grade, students will develop an understanding of the characteristics of living things.

Example Indicators

- Describe the differences between plants and animals.
- Describe the various structures of plants and animals necessary for survival and reproduction.
- Describe how internal stimuli (e.g., hunger) and external stimuli (e.g., changes in the environment) affect behavior of living things.

4.4.2 By the end of fourth grade, students will develop an understanding of the life cycles of living things.

Example Indicators

- Describe the life cycle of an organism.
- Identify inherited characteristics of living things (e.g., color and number of eyes).
- Identify learned characteristics of living things (e.g., language or hunting for food).

4.4.3 By the end of fourth grade, students will develop an understanding of living things and environments.

Example Indicators

- Diagram a food chain.
- Explain how environmental changes affect behavior and survival of living things.
- Describe how humans and other living things cause both positive and negative changes in their environment.

4.5 Earth and Space Science

Earth and space science focuses on the science facts, concepts, principles, theories, and models that are important for all students to know, understand, and use.

4.5.1 By the end of fourth grade, students will develop an understanding of the characteristics of earth materials.

Example Indicators

- Identify characteristics of soils, minerals, rocks, water, and the atmosphere.
- List earth materials that are used by humans (e.g., water, fossil fuels, ores, soils).
- Select the best earth material for a specific human use (e.g., marble–buildings, clay–pottery, coal–heat).
- Describe an ancient environment based on fossil evidence.

4.5.2 By the end of fourth grade, students will develop an understanding of objects in the sky.

Example Indicator

- Observe and describe how objects move in patterns (e.g., sun, moon, stars, and clouds).

4.5.3 By the end of fourth grade, students will develop an understanding of the changes in the earth and sky.

Example Indicators

- Describe how slow processes (e.g., erosion) and rapid processes (e.g., earthquakes)~~,~~ change the earth's surface.
- Describe and measure changes in weather (e.g., temperature, precipitation, and wind direction and speed).

4.6 Science and Technology

An understanding of science and technology establishes connections between the natural and designed world, by linking science with technology.

4.6.1 By the end of fourth grade, students will develop an understanding of technological design.

Example Indicators

- Identify a simple problem.
- Propose a solution to a simple problem.
- Implement the proposed solution.
- Evaluate the implementation.
- Communicate the problem, design, and solution.

4.6.2 By the end of fourth grade, students will develop an understanding of science and technology.

Example Indicators

- Identify tools or techniques that use scientific knowledge to solve problems.
- Identify, investigate, and solve a problem in the home or school.

4.6.3 By the end of fourth grade, students will develop an understanding of the abilities to distinguish between natural objects and objects made by humans.

Example Indicator

- Classify an object as either natural or manufactured.

4.7 Science in Personal and Social Perspectives

A personal and social perspective of science helps a student understand and act on personal and social issues. This perspective builds a foundation for future decision making.

4.7.1 By the end of fourth grade, students will develop an understanding of personal health.

Example Indicators

- Explain how the body uses food and how various foods contribute to health.
- Describe how different substances (e.g., tobacco, alcohol, and drugs) can damage the body and alter how it functions.

4.7.2 By the end of fourth grade, students will develop an understanding of the types of resources.

Example Indicators

- List examples of resources which are basic materials (e.g., air, water, and soil).
- List examples of resources produced from basic materials (e.g., food, fuel, and building materials).
- List examples of resources which are intangible materials (e.g., beauty, security, and quiet places).
- Research and report on the supply of various resources.

4.7.3 By the end of fourth grade, students will develop an understanding of environmental changes.

Example Indicator

- Distinguish between natural environmental changes and human influenced environmental changes.

4.7.4 By the end of fourth grade, students will develop an understanding of how science and technology helps communities resolve problems.

Example Indicator

- Research and explain how science and technology affect the quality of life.

4.8 History and Nature of Science

The history and nature of science illustrates different aspects of scientific inquiry, the human aspects of science, and the role of science in the development of various cultures.

4.8.1 By the end of fourth grade, students will develop an understanding of science as a human endeavor.

Example Indicators

- Research and report on the contributions to science and technology throughout history by men and women scientists of diverse cultures.
- Research and report on how science is used in different careers.
- Research and report on how current scientific discoveries illustrate that science is an ongoing process.

Grades 5-8

At the middle school level, students expand their scientific inquiry skills through knowledge, observations, ideas, and questions. Middle school students will begin to recognize the relationships between explanation and evidence. They understand that background knowledge and theories guide the design of investigations, the types of observations made, and the interpretation of data. Student investigations will shape and modify students' background knowledge.

8.1 Unifying Concepts and Processes

Unifying concepts and processes help students think about and integrate a range of basic ideas which builds an understanding of the natural world.

8.1.1 By the end of eighth grade, students will develop an understanding of systems, order, and organization.

Example Indicators

- Recognize and describe key parts and functions of any system.
- Analyze and predict the interactions within a system and between systems.
- Create and use classification schemes.
- Interpret cause and effect relationships within and between systems.

8.1.2 By the end of eighth grade, students will develop an understanding of evidence, models, and explanation.

Example Indicators

- Collect, manipulate, and analyze data from an experiment.
- Observe and develop models (e.g., physical, mathematical, mental, and computer simulations).
- Interpret and explain results of experimentation.
- Analyze whether or not investigative procedures and conclusions are reasonable.

8.1.3 By the end of eighth grade, students will develop an understanding of change, constancy, and measurement.

Example Indicators

- Select and use appropriate measurement units.
- Quantify changes in systems (e.g., magnitude, direction, and rate).
- Apply English and metric systems of measurements.
- Investigate and describe changes in terms of scale, rate, and pattern.

8.1.4 By the end of eighth grade, students will develop an understanding of form and function.

Example Indicator

- Demonstrate how the design of an object makes it possible for that object to perform a specialized task (e.g., a bicycle or an artificial heart).

8.2 Science as Inquiry

Science as inquiry requires students to combine processes and scientific knowledge with scientific reasoning and critical thinking to develop their understanding of science.

8.2.1 By the end of eighth grade, students will develop the abilities needed to do scientific inquiry.

Example Indicators

- Identify questions and form hypotheses that can be examined through scientific investigations.
- Design and conduct a scientific investigation.
- Use appropriate tools and techniques to gather, analyze, and interpret data.
- Given evidence, develop descriptions, explanations, predictions, and models.
- Show the relationship between evidence and explanations.
- Recognize and analyze alternative explanations and predictions.
- Communicate scientific procedures and explanations.
- Use mathematics in scientific inquiry.

8.3 Physical Science

Physical science focuses on the science facts, concepts, principles, theories, and models that are important for all students to know, understand, and use.

8.3.1 By the end of eighth grade, students will develop an understanding of properties and changes of properties in matter.

Example Indicators

- Investigate and demonstrate that characteristic properties of a substance (e.g., density, boiling point, and solubility) do not depend on the amount of the substance.
- Observe, describe, and measure physical and chemical properties of matter.
- Explain that all matter is composed of elements which may combine in a variety of ways to form compounds.
- Investigate and explain that in chemical reactions new properties are created and total mass is conserved.

8.3.2 By the end of eighth grade, students will develop an understanding of motion and forces.

Example Indicators

- Investigate and describe the motion of an object by its position, direction of motion, and speed.
- Investigate and demonstrate that the speed and/or direction of an object changes when a force is applied to that object.

8.3.3 By the end of eighth grade, students will develop an understanding of the forms of energy and how energy is transferred.

Example Indicators

- Investigate and describe the transfer of light energy.
- Investigate and demonstrate how energy is transferred using simple machines.
- Investigate and describe how heat is transferred from a warmer object to a cooler object until both reach the same temperature.
- Investigate and describe the properties and transfer of sound energy.
- Investigate and describe the transfer of energy from electrical and magnetic sources to different energy forms (e.g., heat, light, sound, and chemical).

8.4 Life Science

Life science focuses on the science facts, concepts, principles, theories, and models that are important for all students to know, understand, and use.

8.4.1 By the end of eighth grade, students will develop an understanding of the structure and function in living systems.

Example Indicators

- Investigate and describe the levels of organizations: cells, tissues, organs, organ systems, whole organisms, and ecosystems.
- Investigate and demonstrate that all living things are composed of cells.
- Investigate and explain how cells sustain life through functions (e.g., growth and nutrition).
- Investigate and describe the specialized function performed by specialized cells (e.g., muscular and skeletal) in multicellular organisms.
- Investigate and describe the human body systems and how they interact.
- Investigate and explain how disease affects the structure and/or function of an organism.

8.4.2 By the end of eighth grade, students will develop an understanding of reproduction and heredity.

Example Indicators

- Investigate and describe how all organisms reproduce through sexual or asexual reproduction.
- Investigate and describe that in many species, offspring receive hereditary information from the female (eggs) and male (sperm).
- Investigate and explain that chromosomes contain genes which influence heredity.
- Investigate and describe the effects of inherited traits and environmental influences on an organism's characteristics.

8.4.3 By the end of eighth grade, students will develop an understanding of regulation and behavior.

Example Indicators

- Investigate and explain how organisms' behaviors enhance their abilities to obtain and use resources, grow, and reproduce.
- Investigate and examine how an organism senses change in its internal or external environment and responds to keep conditions within a required range.
- Investigate and explain how behavior is a response to internal and external stimuli determined by heredity and experience.
- Investigate and explain how an organism's behavior evolves through environmental adaptation.

8.4.4 By the end of eighth grade, students will develop an understanding of populations and ecosystems.

Example Indicators

- Investigate and describe that a population consists of all individuals of a species at a given place and time.
- Investigate and analyze the living and nonliving factors that determine the number of organisms an ecosystem can support.
- Describe an organism by the function it serves in an ecosystem (e.g., producer, consumer, and decomposer).
- Investigate and explain how energy entering ecosystems as sunlight is transferred by producers into chemical energy through photosynthesis, and that energy then passes from organism to organism in food webs.

8.4.5 By the end of eighth grade, students will develop an understanding of diversity and adaptations of organisms.

Example Indicators

- Explain how internal structures, similarity of chemical processes, (e.g., photosynthesis and respiration) and

evidence of common ancestry demonstrate unity among organisms.
- Investigate and explain how organisms adapt to living and nonliving factors in a biome.
- Investigate and explain how environmental changes created by nature and by humans may cause species extinction.

8.5 Earth and Space Science

Earth and space science focuses on the science facts, concepts, principles, theories, and models that are important for all students to know, understand, and use.

8.5.1 By the end of eighth grade, students will develop an understanding of the structure of the earth.

Example Indicators

- Investigate and describe the crust, mantle, and core of the earth.
- Investigate and describe how a combination of constructive and destructive forces create land forms.
- Investigate and describe the composition of soils.
- Investigate and describe the water cycle.
- Investigate and describe the composition of the atmosphere at different altitudes.
- Investigate and describe the influence of topography, location, and oceans on climate.
- Investigate and describe the effect of living organisms on weathering and the atmosphere.

8.5.2 By the end of eighth grade, students will develop an understanding of the earth's history.

Example Indicators

- Investigate and describe how earth processes that occur today (e.g., volcanism, weather, and erosion) are similar to those that occurred in the past.
- Investigate and use the fossil record to provide evidence and explain how environmental conditions have changed.

8.5.3 By the end of eighth grade, students will develop an understanding of the earth in the solar system.

Example Indicators

- Investigate and list the components of the solar system.
- Investigate and describe the motion of objects in the solar system that support the concepts of day, year, eclipses, and phases of the moon.
- Investigate and describe the influence of gravity on objects in the solar system.
- Investigate and describe the sun as the major source of energy that influences the atmosphere and the earth's surface.
- Investigate and describe the effect of the tilt of the earth's axis on seasons.

8.6 Science and Technology

An understanding of science and technology establishes connections between the natural and designed world, linking science and technology.

8.6.1 By the end of eighth grade, students will develop an understanding of technological design.

Example Indicators

- Identify problems for technological design.
- Design a solution or product.
- Implement a proposed design.
- Evaluate completed technological designs or products.
- Communicate the process of technological design.

8.6.2 By the end of eighth grade, students will develop an understanding of science and technology.

Example Indicators

- Distinguish between scientific inquiry (asking questions about the natural world) and technological design (using science to solve practical problems).
- Describe how science and technology are reciprocal.
- Assess the avoidable and unavoidable limits of a technological design.
- Recognize that solutions have intended and unintended consequences.

8.7 Science in Personal and Social Perspectives

A personal and social perspective of science helps a student understand and act on personal and social issues. This perspective builds a foundation for future decision making.

8.7.1 By the end of eighth grade, students will develop an understanding of personal health.

Example Indicators

- Identify and research substances harmful to human beings in the natural environment (e.g., radon, lead, and nitrates).
- Investigate and explain how personal choices can directly affect a person's health (e.g., exercise, nutrition, and use of drugs).

8.7.2 By the end of eighth grade, students will develop an understanding of relationships among populations, resources, and environments.

Example Indicators

- Investigate and describe how population levels affect resources and the environment.
- Investigate and understand that the causes of environmental degradation and resource depletion vary locally and globally.

8.7.3 By the end of eighth grade, students will develop an understanding of natural hazards.

Example Indicators

- Investigate and describe the effect of natural hazards on the environment (e.g., earthquakes, landslides, wildfires, floods, and storms).
- Investigate and describe human activities (e.g., urban growth, land use, and waste disposal) which can accelerate many natural changes.

8.7.4 By the end of eighth grade, students will develop an understanding of risks and benefits.

Example Indicators

- Analyze a type of hazard (e.g., natural, chemical, or biological) to evaluate the options for reducing or eliminating human risk.
- Describe how perceptions of risks and benefits influence personal and social decision (e.g., seat belt usage and waste disposal procedures).

8.7.5 By the end of eighth grade, students will develop an understanding of science and technology in society.

Example Indicators

- Explain that the effect of science on society is neither entirely beneficial nor entirely detrimental.
- Describe how societal challenges and priorities influence research priorities.
- Explain why science cannot answer all questions and technology cannot solve all human problems or meet all

human needs.

8.8 History and Nature of Science

An understanding of the history and nature of science illustrates different aspects of scientific inquiry, the human aspects of science, and the role of science in the development of various cultures.

8.8.1 By the end of eighth grade, students will develop an understanding of science as a human endeavor.

Example Indicators

- Investigate and understand that women and men of various social and ethnic backgrounds, working alone or in teams, engage in the activities of science, engineering, and related fields.
- Investigate and understand that science requires different abilities based on the type of inquiry and relies upon basic human qualities and scientific habits of mind.
- Explain the need for ethical codes followed by scientists (e.g., humane treatment of animals and truth in reporting).

8.8.2 By the end of eighth grade, students will develop an understanding of the nature of science.

Example Indicators

- Formulate and test a hypothesis using observations, experiments, and models.
- Use questioning, response to criticism, and open communication when defending a conclusion.
- Evaluate the results of scientific investigations, experiments, observations, theoretical models, and the explanations proposed by other scientists.
- Understand that scientific theories are based on observations, governed by rules of reasoning, and used to predict events.

8.8.3 By the end of eighth grade, students will develop an understanding of the history of science.

Example Indicator

- Research and describe the difficulties experienced by scientific innovators who had to overcome commonly held beliefs of their times to reach conclusions that we now take for granted.

Grades 9-12

Senior high students should be able to understand scientific inquiry at increasingly higher levels of sophistication. Questions and issues relevant to students should form the basis of investigations. An adequate knowledge base and an understanding of the concepts that guide inquiry are needed to assure success. Students should learn how to analyze evidence and evaluate their own explanations and those of scientists.

12.1 Unifying Concepts and Processes

Unifying concepts and processes help students think about and integrate a range of basic ideas which builds an understanding of the natural world.

12.1.1 By the end of twelfth grade, students will develop an understanding of systems, order, and organization.

Example Indicators

- Predict and evaluate how change within a system affects that system.
- Design solutions to problems identified within a system.

12.1.2 By the end of twelfth grade, students will develop an understanding of evidence, models, and explanation.

Example Indicators

- Create a physical, mental, or mathematical model to show how objects and processes are connected.
- Test the usefulness of a model by comparing its predictions to actual observations.
- Understand that the way data are displayed affects interpretation.
- Evaluate the reasonableness of answers to problems.
- Understand that larger well-chosen samples produce more accurate estimates of the characteristics of the total population.
- Understand that a correlation between two variables doesn't mean that either one causes the other.

12.1.3 By the end of twelfth grade, students will develop an understanding of change, constancy, and measurement.

Example Indicators

- Use powers of ten to represent large and small numbers
- Compare data for two groups by using averages and ranges of values.
- Understand that measurement errors may affect results of calculations.
- Describe rate of change by comparing one measured quantity to another measured quantity.
- Investigate and describe how different characteristics, properties, or relationships within a system change as their dimensions increase or decrease.

12.1.4 By the end of twelfth grade, students will develop an understanding of form and function.

Example Indicator

- Explain function by referring to form and explain form by referring to function.

12.1.5 By the end of twelfth grade, students will develop an understanding of change over a period of time.

Example Indicators

- Identify the series of changes that occur in objects, organisms, and natural and human designed systems.
- Explain how a system at equilibrium is affected by change.

12.2 Science as Inquiry

Science as inquiry requires students to combine processes and scientific knowledge with scientific reasoning and critical thinking to develop their understanding of science.

12.2.1 By the end of twelfth grade, students will develop the abilities needed to do scientific inquiry.

Example Indicators

- Formulate questions and identify concepts that guide scientific investigations.
- Design and conduct scientific investigations.
- Use technology and mathematics to improve investigations and communications.
- Formulate and revise scientific explanations and models using logic and evidence.
- Recognize and analyze alternative explanations and models.
- Communicate and defend a scientific argument.

12.3 Physical Science

Physical science focuses on the science facts, concepts, principles, theories, and models that are important for all students to know, understand, and use.

12.3.1 By the end of twelfth grade, students will develop an understanding of the structure of the atom.

Example Indicators

- Investigate and describe the structure of atoms, focusing on properties of subatomic particles.
- Investigate and explain the types of nuclear reactions.
- Investigate and describe the effect of electrical and nuclear forces which hold atoms together.

12.3.2 By the end of twelfth grade, students will develop an understanding of the structure and properties of matter.

Example Indicators

- Investigate and understand that atoms interact with one another by transferring or sharing electrons.
- Investigate and explain the periodic table of elements in terms of repeating patterns of physical and chemical properties.
- Investigate and describe how the structure of an atom determines the chemical properties of an element.
- Investigate and explain how the interactions among the molecules of a compound determine its physical and chemical properties.
- Investigate and use changes in energy to explain the differences among the states of matter.
- Investigate and describe the bonding of carbon atoms in chains and rings to produce compounds essential to life.

12.3.3 By the end of twelfth grade, students will develop an understanding of chemical reactions.

Example Indicators

- Investigate and describe common chemical reactions.
- Investigate and describe the change of energy as a result of chemical reactions.
- Investigate and describe how electrons are involved in bond formation during chemical reactions.
- Investigate and describe the factors influencing the rates of chemical reactions, including catalysts.

12.3.4 By the end of twelfth grade, students will develop an understanding of motions and forces.

Example Indicators

- Investigate and understand the effect of forces on the motion of objects.
- Investigate and understand gravity as an attractive force that each mass exerts on any other mass.
- Investigate and understand electrical force as a force that exists between any two charged objects.

- Investigate and describe an electric field a magnetic field, and the interaction between them.

12.3.5 By the end of twelfth grade, students will develop an understanding of the conservation of energy and increase in disorder.

Example Indicators

- Understand that the total energy in the universe is constant and can never be destroyed.
- Investigate and distinguish between kinetic energy and potential energy.
- Investigate and describe heat transfer in terms of conduction, convection, and radiation.
- Investigate and give examples of how systems tend to become more disorderly over time.

12.3.6 By the end of twelfth grade, students will develop an understanding of the interactions of energy and matter.

Example Indicators

- Investigate and understand that all waves possess and transfer energy.
- Understand that electromagnetic waves result when a charged object accelerates.
- Investigate and illustrate how wavelength and frequency of waves are inversely related.
- Investigate and understand that the energy of waves can be changed into other forms of energy, just as other forms of energy can be transformed into wave energy.
- Investigate and understand that atoms or molecules can be identified by spectral analysis.
- Investigate and describe how the composition and temperature of a material affect electron flow.

12.4 Life Science

Life science focuses on the science facts, concepts, principles, theories, and models that are important for all students to know, understand, and use

12.4.1 By the end of twelfth grade, students will develop an understanding of the cell.

Example Indicators

- Investigate and describe the form and function of subcellular structures that regulate cell-activities.
- Investigate and describe cell functions (e.g., photosynthesis, respiration, cell division).
- Investigate and understand that complex multicellular organisms are formed as highly organized arrangements of differentiated cells.

12.4.2 By the end of twelfth grade, students will develop an understanding of the molecular basis of heredity.

Example Indicators

- Investigate and describe how DNA carries the genetic code.
- Investigate and understand that genetic variation occurs when genetic information is transmitted during sexual reproduction.
- Investigate and explain how some mutations could help, harm or have no effect on individual organisms.
- Investigate and explain how mutations in sex cells, but not in body cells, could be passed on to offspring.

12.4.3 By the end of twelfth grade, students will develop an understanding of the theory of biological evolution.

Example Indicators

- Understand that the concept of biological evolution is a theory which explains the consequence of the interactions of: (1) the potential for a species to increase its numbers; (2) the genetic variability of offspring due to mutation and recombination of genes; (3) a finite supply of the resources of life; and (4) the ensuing selection by the environment of those offspring better able to survive and leave offspring.
- Investigate and use the theory of biological evolution to explain diversity of life.
- Investigate whether natural selection provides a scientific explanation of the fossil record and the molecular

similarities among the diverse species of living organisms.
- Investigate and use biological classifications based on similarities.

12.4.4 By the end of twelfth grade, students will develop an understanding of the interdependence of organisms.

Example Indicators

- Investigate and understand that atoms and molecules cycle among living and nonliving components of the biosphere.
- Investigate and describe the flow of energy through ecosystems, in one direction, from producers to herbivores to carnivores and decomposers.
- Investigate and cite examples of organisms cooperating and competing in ecosystems.
- Investigate and understand that interactions among organisms are affected by the conflict between an organism's capacity to produce infinite populations and the finite amount of resources.
- Investigate and describe how humans modify the ecosystem as a result of population growth, technology, and consumption.

12.4.5 By the end of twelfth grade, students will develop an understanding of matter, energy, and organization in living systems.

Example Indicators

- Investigate and understand that living systems require a constant input of energy to maintain their chemical and physical organization.
- Investigate and understand that producers use solar energy to combine molecules of carbon dioxide and water into organic compounds.
- Investigate and explain how distribution and abundance of different organisms in ecosystems are limited by the availability of matter and energy and the ability of the ecosystem to recycle materials.

12.4.6 By the end of twelfth grade, students will develop an understanding of the behavior of organisms.

Example Indicators

- Investigate and describe how nervous systems function in multicellular animals.
- Investigate and describe how organisms respond to internal changes and external stimuli.
- Investigate and explain how the behavioral patterns of organisms have evolved through natural selection.
- Investigate and understand that behavioral biology relates to humans since it provides links to psychology, sociology, and anthropology.

12.5 Earth and Space Science

Earth and space science focuses on the science facts, concepts, principles, theories, and models that are important for all students to know, understand, and use.

12.5.1 By the end of twelfth grade, students will develop an understanding of energy in the earth system.

Example Indicators

- Investigate and distinguish between internal sources of energy (e.g., radioactive decay and gravitational energy) and external sources of energy (e.g., the sun), and explaining how both provide energy to the earth systems.
- Investigate and explain how the outward transfer of earth's internal heat drives convection in the mantle that propels the plates comprising the earth's surface.
- Investigate and explain how global climate is determined by energy transfer from the sun and is influenced by dynamic processes (e.g., cloud formation and the earth's rotation) and static conditions (e.g., the position of mountain ranges and oceans).

12.5.2 By the end of twelfth grade, students will develop an understanding of geochemical cycles.

Example Indicator

- Investigate and diagram how elements and compounds on earth move among reservoirs in the solid earth, oceans, atmosphere, and organisms as part of geochemical cycles.

12.5.3 By the end of twelfth grade, students will develop a scientific understanding of the origin of the earth system.

Example Indicators

- Contrast the early earth with the planet we live on today.
- Investigate and estimate geologic time by observing rock sequences and using fossils to correlate the sequences at various locations.
- Predict when rocks were formed by using known decay rates of radioactive isotopes in rocks.
- Investigate and relate how the interactions among the solid earth, oceans, atmosphere, and organisms affect the ongoing evolution of the earth.

12.5.4 By the end of twelfth grade, students will develop a scientific understanding of the origin of the universe.

Example Indicators

- Describe and analyze various theories on the origin of the universe.
- Describe various theories on the formation of galaxies.
- Describe the life cycle of a star.

12.6 Science and Technology

An understanding of science and technology establishes connections between the natural and designed world, linking science to technology.

12.6.1 By the end of twelfth grade, students will develop an understanding of technological design.

Example Indicators

- Propose designs and choose between alternative solutions of a problem.
- Implement the selected solution.
- Evaluate the solution and its consequences.
- Communicate the problem, process, and solution.

12.6.2 By the end of twelfth grade, students will develop an understanding about science and technology.

Example Indicators

- Explain how science advances with the introduction of new technology.
- Understand creativity, imagination, and a good knowledge base are all needed to advance the work of science and engineering.
- Contrast the reasons for the pursuit of science and the pursuit of technology.
- Contrast the reporting of scientific knowledge and the reporting of technical knowledge.

12.7 Science in Personal and Social Perspectives

A personal and social perspective of science helps a student understand and act on personal and social issues. This perspective builds a foundation for future decision making.

12.7.1 By the end of twelfth grade, students will develop an understanding of personal and community health.

Example Indicators

- Investigate and describe the effect of nutritional balance on growth, development, and personal well-being.
- Investigate and explain how diseases are prevented, controlled, and cured.
- Investigate and explain how genetic traits affect a person's health.
- Investigate and analyze risks and benefits in making decisions about personal and community health.

12.7.2 By the end of twelfth grade, students will develop an understanding of the effects of population change.

Example Indicators

- Investigate and identify causes of population growth or decline.
- Investigate and explain how various factors influence birth rates and death rates.
- Investigate and predict how population change may impact resource use and environments.

12.7.3 By the end of twelfth grade, students will develop an understanding of natural resources.

Example Indicators

- Investigate and explain how human populations use environmental resources to maintain and improve their existence.
- Investigate and understand that the earth has renewable and finite resources.
- Investigate and understand the limitations of natural systems to renew and recycle resources.

12.7.4 By the end of twelfth grade, students will develop an understanding of environmental quality.

Example Indicators

- Investigate and describe how the positive and negative consequences of human intervention or nonintervention impact the ecosystem.
- Investigate and explain factors which may influence environmental quality.

12.7.5 By the end of twelfth grade, students will develop an understanding of natural and human-induced hazards.

Example Indicators

- Investigate and describe how human activities increase or reduce the potential for hazards.
- Investigate and distinguish between slowly and rapidly occurring natural hazards and their impact on the environment.

12.7.6 By the end of twelfth grade, students will develop an understanding of the role of science and technology in local, national, and global challenges.

Example Indicators

- Understand that knowledge of basic concepts about scientific and technological challenges should precede active debate.
- Investigate and understand that social issues and challenges may affect advancements in science and technology.
- Understand that science and technology are essential social enterprises that indicate what could happen, but not what should happen.

12.8 History and Nature of Science

The history and nature of science illustrates different aspects of scientific inquiry, the human aspects of science, and the role that science has played in the development of various cultures.

12.8.1 By the end of twelfth grade, students will develop an understanding of science as a human endeavor.

Example Indicators

- Demonstrate ethical scientific practices (e.g., informing research subjects about risks and benefits, humane treatment of animals, truthful reporting, public disclosure of work, and peer review).
- Examine and understand the societal, cultural, and personal beliefs that influence scientists.
- Recognize science as one way of answering questions and explaining the natural world.

12.8.2 By the end of twelfth grade, students will develop an understanding of the nature of scientific knowledge.

Example Indicators

- Demonstrate the use of empirical standards, logical arguments, and skepticism in science.
- Create scientific explanations consistent with experimental and observational evidence; make accurate predictions; strive to be logical; respect the rules of evidence; accept criticism; report methods and procedures; and make knowledge public.
- Understand that all scientific knowledge is, in principle, subject to change as new evidence becomes available.

12.8.3 By the end of twelfth grade, students will develop an understanding of the history of science.

Example Indicators

- Investigate and describe the contributions of diverse cultures to scientific knowledge and technological inventions.
- Understand that changes in scientific knowledge evolve over time and almost always build on earlier knowledge.
- Understand that some advancements in science and technology have long-lasting effects on society.